Fermilab

Particle Physics Division
Mechanical Department Engineering Note

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Project Internal Reference:

Project: NOvA

Title: TEC Flow

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Key Words: NOvA, TEC

Applicable Codes:

Abstract Summary:

The following is an analysis of the flow rate through a NOvA detector TEC. The flow rate was recorded at several different levels of head for analysis

Picture 1: Test set-up with TEC hook up boxed in blue and enlarged below.

Picture 2: Zoom in on TEC hookup

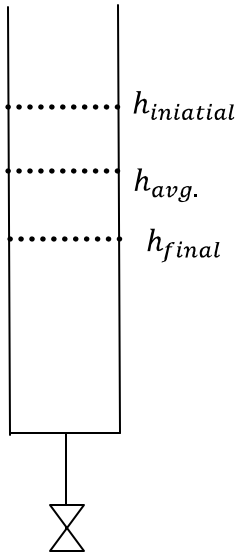
Discussion/Summary

In order to measure flow rate v. feet of head through the TEC, a 1'' nominal diameter PVC pipe was set up to hang vertically using two sets of metal braces attached to two railings parallel to the ground, and a level. Due to the TEC hoses being flimsy, the TEC itself was c-clamped to a steel tube base with the hoses coming out parallel to the floor (top hose to PVC pipe, bottom hose into secured 100 mL graduated cylinder). The on/off control valve is located on the end of the bottom hose, feeding directly into the graduated cylinder. Height measurements were marked on the PVC pipe starting 1 foot from the center of the clamped TEC, and incrementing up to 7 feet in ½ foot intervals.

Flow data was taken by filling the vertical pipe to the marked increments, opening the control valve and allowing it to fill to 100 mL (*Note: at 1 ft the pipe contained less than 100 mL so a different value was used)*, and timing how long it took with a stopwatch. When timing the flow, two trials were done for each height and an average time was used for closest accuracy. When considering feet of head an average must also be used due the height of water being different before and after the valve is opened and shut again.

The average head was computed as follows:

- $Head_{avg} = height_{initial} - \left(\frac{height_{initial} - height_{final}}{2}\right)$
- 100 mL in graduated cylinder = 7.5 inches in vertical pipe
- 7.5'' = 0.625 ft = $height_{initial} - height_{final}$
- $\left(\frac{height_{initial} - height_{final}}{2}\right)$ = 0.3125 feet
- $\boldsymbol{Head_{avg} = height_{initial} - 0.3125\ \text{ft}}$

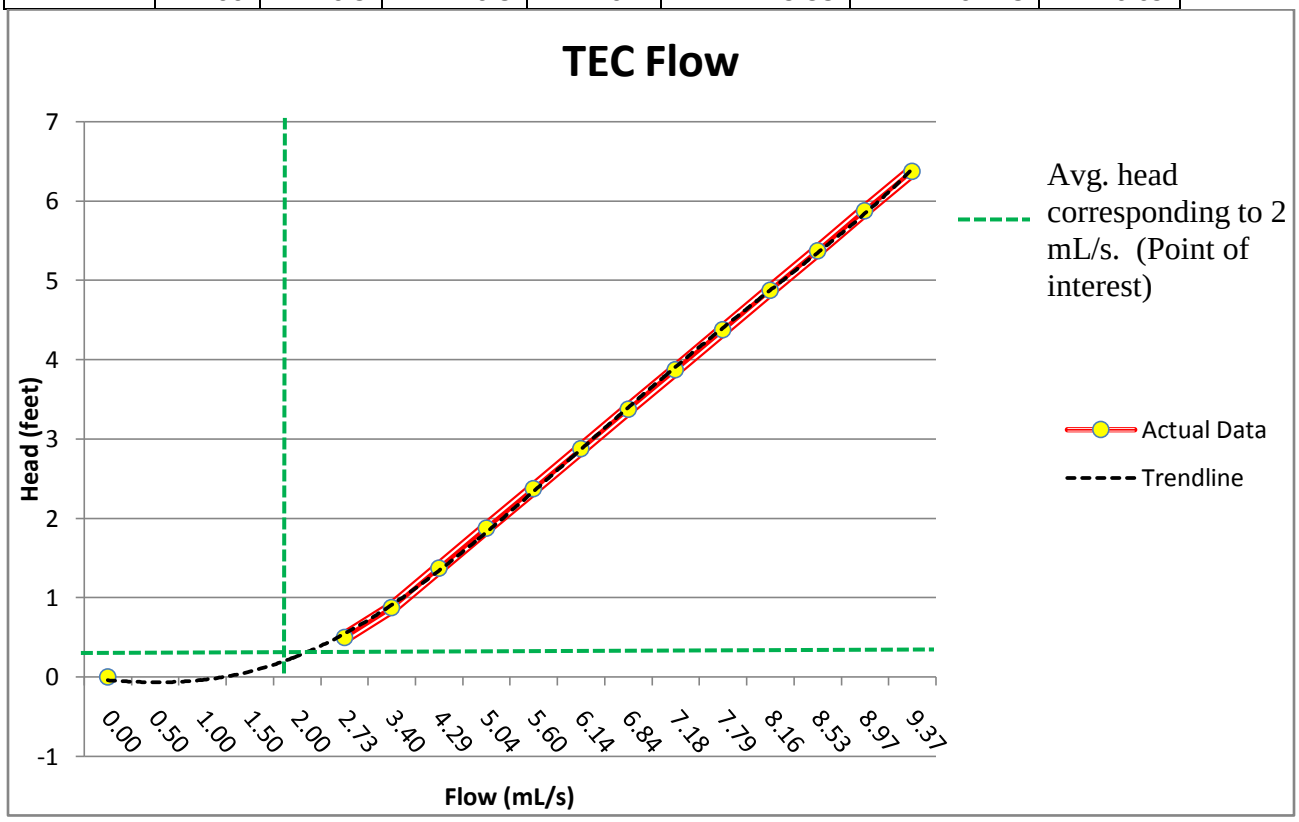


The flow rate was computed as follows:

- (mL/s) → $Flow_{mL/s} = \frac{Volume\ filled\ (mL)}{time\ (s)}$
- (Gpm) → $Flow_{Gpm} = Flow_{mL/s} * \frac{1\ L}{1000\ mL} * 0.2641779 \frac{G}{L} * 60 \frac{s}{min}$

The following data was gathered:

ft increment	mL filled	trial 1 time (s)	trial 2 time (s)	time average (s)	Flow Rate (mL/s)	Flow Rate (Gpm)	head avg (ft)
1	63	23.8	22.5	23.1	2.73	0.0432	0.5
1.5	100	29.3	29.5	29.4	3.40	0.0540	1.19
2	100	23.1	23.5	23.3	4.29	0.0680	1.69
2.5	100	19.9	19.8	19.9	5.04	0.0798	2.19
3	100	17.9	17.8	17.9	5.60	0.0887	2.69
3.5	100	16.3	16.3	16.3	6.14	0.0973	3.19
4	100	14.7	14.6	14.6	6.84	0.108	3.69
4.5	100	14.0	13.9	13.9	7.18	0.114	4.19
5	100	12.9	12.8	12.8	7.79	0.123	4.69
5.5	100	12.4	12.1	12.3	8.16	0.129	5.19
6	100	11.8	11.7	11.7	8.53	0.135	5.69
6.5	100	11.3	11.0	11.1	8.97	0.142	6.19
7	100	10.5	10.8	10.7	9.38	0.148	6.69



Flow Rate v. avg. Head from data collected is shown in red; and a dashed 5th order polynomial trend line has been fitted to show flow rates below ½' of head.

➔ At 2 mL/s the average head is about 0.4 feet or about 4.8 inches (dashed green line).